technical importance is the RT field arrangement, where the trend is using more complex dose planning. However, in the complex IMRT plans often more low-dose is distributed into large volumes of organs at risk, and that may be a bad decision increasing the risk of late morbidity. More patients are receiving adjuvant systemic therapies today compared to previously, and these therapies may partly reduce the gain from RT because they themselves reduce the risk of LRR, and partly because they may increase the risk of late morbidity after RT. This may be the case for RT-related morbidities like the risk of ischemic heart disease, damage to the brachial plexus, risk of lymph oedema and impaired shoulder movement. The risk of RT-induced second cancer is also important since it may be as high as 1:200, thus of the same magnitude as the risk of RT-induced heart disease (Grantzau et al, R&O, 2013).
In conclusion, new studies are now supporting earlier studies showing gain from regional RT also in pN1 patients, but there is still a risk of RT related morbidity which must be dealt with. Therefore we need focus on identifying those patients who benefit from the RT, and we need a solid basis for selecting those patients who can be spared from RT. Studies on gene risk profiles to help us identify patients with benefit from RT are ongoing.

Teaching Lecture: SBRT for primary lung tumours: What is optimal dose and fractionation?

SP-0348
SBRT for primary lung tumours: What is optimal dose and fractionation?
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SBRT for lung tumors has become an effective and safe routine procedure in many centers. However, due to historical developments, there is still a large diversity in doses and fractionation regimens.
In this teaching lecture, an overview of current dose and fractionation regimens for different clinical scenarios of lung SBRT will be given and discussed in the light of outcome and normal tissue toxicity.

Teaching Lecture: What are the reasons why molecular drugs fail together with radiotherapy?

SP-0349
What are the reasons why molecular drugs fail together with radiotherapy?
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Abstract not received.

Teaching Lecture: Improving detector response in small photon fields

SP-0350
Improving detector response in small photon fields
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Classically detector response in small fields was considered to be influenced by two key factors: volume-averaging and differences between the photon spectra of small and large fields. Therefore it was thought that an ideal detector should be small in comparison to the dimensions of the fields it was used to measure, and have an atomic composition similar to water so that detector response would vary with fluence spectrum in the same way as dose-to-water. Consequently small air ion chambers and diamond detectors were identified as promising small field dosimeters.
For some time it has also been known that differences between the fluence spectra of small and intermediate (4×4 cm^2) fields are insufficiently large to generate appreciable variations in the response of silicon-based detectors relative to water, and thus that diode detectors may be another good option for small field dosimetry, provided their calibration is 'daisy-chained' from the usual 10×10 cm^2 reference fields via a 3×3 or 4×4 cm^2 intermediate.
More recently it has been understood that as lateral electronic equilibrium (LEE) begins to break down (in fields narrower than 1.5 cm for a 6 MV beam) so response begins to be substantially influenced by the density of the detector sensitive volume (Figure 1), a non-classical factor which has no impact on response in wider fields. This finding has two implications for small field dosimetry: (i) it allows a small field to be defined physically as one in which LEE does not hold, rather than operationally with respect to detector size; (ii) it raises questions about the optimality of some air ion chambers, diodes and diamond detectors for small field dosimetry, as the sensitive volumes of these detectors have densities .001, 2.3 and 3.5 that of water, and it suggests that liquid ion chambers and plastic scintillators with roughly unit densities may make better detectors.
Very recently, however, it has been appreciated that response is influenced not just by the density of a detector sensitive volume, but also by the densities of detector components lying close to it; and therefore that the response of diodes, diamond detectors, and potentially air ion chambers in small fields can be improved by using density compensation. In the case of a solid-state detector this involves building a small air cavity into the detector, upstream of the sensitive volume. In this lecture more details are provided of detector response in small fields and the factors underlying it. Density compensation techniques are also outlined, and results from an evaluation of a prototype density-compensated PTW diode-Air detector are presented.

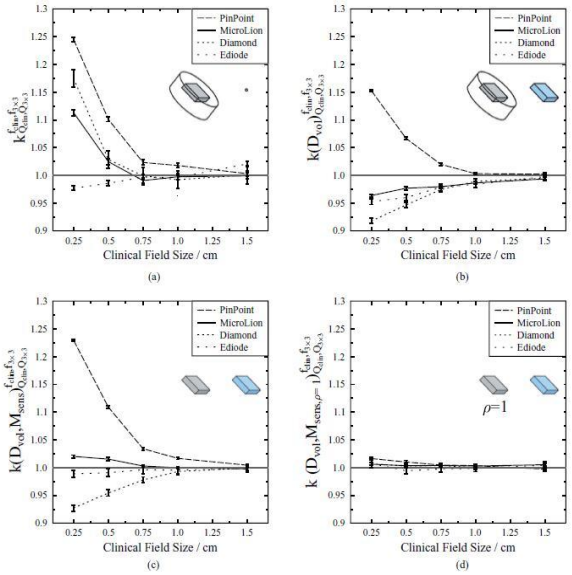

Figure 1. Response of four detectors in small fields, defined via the Alfonso k correction factor as the dose-to-water to dose-to-detector ratio in a small field divided by the same ratio in a reference (3×3 cm^2) field, plotted for: (a) the whole detector vs a point of water; (b) whole detector vs a water voxel of the same size as the detector sensitive volume; (c) sensitive volume alone versus water voxel of the same size; (d) sensitive volume with density adjusted to that of water vs water voxel of the same size.

Teaching Lecture: Radiobiology on particle therapy

SP-0351

Radiobiology in particle therapy

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Densely ionizing radiation deposits the energy by electromagnetic or nuclear interactions along the tracks. This non-uniform energy deposition patterns generates a high number of clustered DNA lesions, which are difficult to repair. Therefore, protons, alpha particles, and heavy ions are generally more effective than X-rays in inducing biological damage. For many years, particle therapy radiobiology concentrated on measurements of the relative biological effectiveness (RBE) of the energetic particles for tumour cell killing, generally using in vitro cell cultures exposed in monolayers at high-energy particle accelerators, such as the BEVALAC (Berkeley, USA), HIMAC (Chiba, Japan), and GSI (Darmstadt, Germany). The RBE-LET relationship is well known, and the large variability reflects the variance of the RBE, which is dependent upon many physical, chemical, and biological parameters. More recently, it has been shown that densely ionizing radiation elicits signaling pathways quite distinct from those involved in the cell and tissue response to photons. The response of the microenvironment to charged particles is therefore under scrutiny, and both the damage in the target and non-target tissues are relevant. Hypofractionation, combined treatment modalities, and dose/LET painting are now under study in several accelerator facilities for clinical translation. Particle radiobiology is therefore now entering into a new phase, where beyond RBE the tissue response is considered. These results may open new applications in cancer therapy with charged particles (hadrontherapy).

Teaching Lecture: Introduction to proton therapy

SP-0352

Introduction to proton therapy

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Proton therapy makes it possible to treat cancer more effectively and with fewer side effects than is often the case with conventional radiotherapy. With proton therapy, the risk of damage to healthy tissues can be brought to a minimum for a number of clinical indications. These attractive properties have led to a rapid expansion of the proton treatment capacity worldwide. As a matter of fact, the number of proton facilities is increasing exponentially and proton therapy will soon be widely available and not merely an exotic option only for a few highly specialised centres. For this reason, there is a need for a broader understanding of proton therapy, its potentials, but also its limitations and potential pitfalls.

Proton therapy is often claimed to be “more precise” than conventional radiotherapy. This is because the dose distribution can be modulated also in the depth direction, contrary to IMRT where the depth dose distribution is more or less invariant with the modulation. This possibility does not, however, necessarily significantly improve the conformity of the high dose volume since e.g. the penumbra in many cases are worse than what can be achieved with photons. The rapid dose fall-off at the end of the proton track can be used to obtain sharp dose gradients and hence a highly tailored dose distribution, but unfortunately, due to uncertainties in the estimated range of the proton beam, this property is not possible to explore to its full potential. The fundamental and remaining advantage with proton therapy is hence the significant reduction to non-target tissues and a reduction in side effects.

For most of the large groups of cancer patients, the highest level of evidence for the superiority of proton treatment over conventional radiotherapy is still lacking. There is an ongoing discussion about the potential ethical dilemma of randomising patients between standard radiotherapy and proton therapy which is “known” to be better. However, a large number of clinical trials are designed and the knowledge regarding the best use of proton therapy will increase over the coming years. What can be assumed with a reasonable high degree of evidence is that proton therapy, correctly applied, will decrease late toxicity and since less dose is deposited in non-target tissues, the risk of developing a new, radiation-induced cancer later in life is significantly reduced. This is of particular importance in paediatric patients.